ZOOPLANKTON, SUSPENDED MATTER AND NEUSTON

FOR THE BLM SURVEYS TO THE EASTERN GULF OF MEXICO

University of South Florida, Department of Marine Science

Principal Investigator:
Peter R. Betzer

Associate Investigator:
Martin A. Peacock

INTRODUCTION

Interest in the impact of oil exploration and subsequent exploitation has provided the need to further explore and understand certain reactive constituents and their cycles within the oceans. These trace constituents of seawater can be excellent indicators of certain types of pollution provided baseline levels have been established.

Trace constituents are concentrated and transported by suspended matter, zooplankton and neuston in a variety of ways. Zooplankton have been shown to transport trace elements through: vertical migrations across mixing barriers (Pearcy and Osterberg, 1967), moulting of exoskeletons (Fowler and Small, 1967), the sinking of skeletal structures after death (Arrhenius, 1963), the incorporation of elements into fast-sinking fecal pellets (Osterberg, et al., 1963), and the passage of elements to a higher trophic level (Osterberg, Pearcy and Curl, 1964). Suspended matter, both biogenic and terrigenous, may have elevated trace metal concentrations from chemical processes such as chelation, adsorption, precipitation and flocculation. This material is often adsorbed to or ingested by small marine zooplankton who concentrate the metal ions and transport them either to the benthos or higher up the food chain.

The concentration levels of different zooplankton populations may vary due to: the amount of the element available (Goldberg, 1957); the temperature and salinity of surrounding waters (Duke, et al., 1969); the population turnover rates (Martin, 1970), and the physiological state of the organisms (Haywood, 1970). Zooplankton populations will show further differences in elemental composition since each population can

consist of up to twelve phyla of very different morphologies and trophic *levels*. Moreover, each species may exhibit vastly different chemical contents (Nicholls, Curl and Bowen, 1959).

Heavy metal pollution has already caused severe losses of shellfish and other commercial fisheries , as well as affecting human health in isolated cases (Merlini, 1971). Heavy metals, unlike the major constituents of seawater, are highly reactive, and much needs to be known about their transport in the marine environment. Suspended matter, neuston , and zooplankton which are able to remove, concentrate and transport trace metals, are thus important in the fluxes of these heavy metals throughout the oceanic environment.

Sample Collection

Suspended matter, zooplankton and neuston samples were collected aboard the R/V TURSIOPS on four transects across the western and southern continental shelves of' Florida, Alabama and Mississippi (Figure 1). The samples were collected during June and September of 1975, and. January of 1976 as part of the MAFLA project. Neuston were collected for analysis during the last two sampling periods. One suspended matter and. zooplankton sample was collected at each of the fifteen stations situated on the transects; two neuston samples (day and night) were collected at these same locations. During the September, 1975, sampling period, one additional sample was collected following Hurricane ELOISE at Station 1205 on the Florida Middle Grounds.

Water *samples* were collected at 10 meters depth on plastic sheathed hydrowire using one 30 ℓ polyvinyl chloride (PVC) Niskin bottle, with an internal rubber closure.

Suspended materials were separated from the water in the 30 ℓ Niskin bottle onto 47 mm diameter, 0.4 μm pore size, Nucleopore[R] membranes. The filtering system, which was closed to atmosphere contamination consisted of 9.5 mm I.D. silicon rubber (leached with 4 N HCl prior to sampling) which carried the water from the Niskin bottle to a high density, linear polyethylene Millipore filter head. To minimize contamination during the sampling period, the disconnected tubing was covered with polyethylene bags. Prier to filtering a new sample the tube was flushed with approximately one liter of that sample. To prevent exposure to shipboard contamination, the filters were loaded prior to sampling and removed after sampling with Teflon[R] tweezers in a clean bench. Filtration was carried out by pressurizing the Niskin bottles with 0.35 kg/cm^2 of filtered nitrogen. In an attempt to prevent any atmospheric contamination
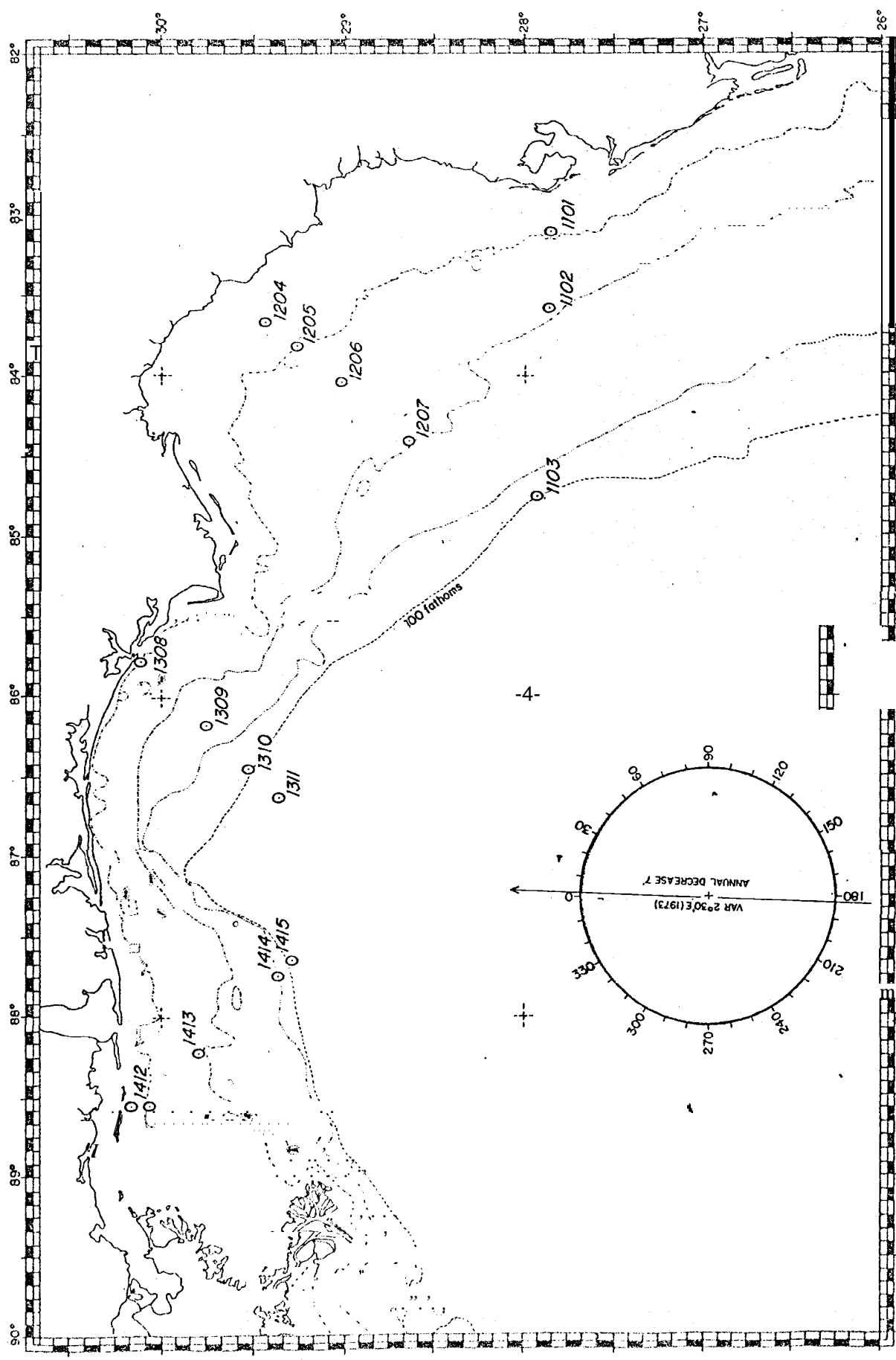
Figure 1. MAFLA Water Column Stations. 1975-1976.

the system was completely sealed. to the atmosphere and was constructed of high density linear polyethylene. To prevent contamination by material in the nitrogen pressure cylinder, two high density polyethylene Milli-pore filter heads containing 47 mm, 0.1 μm pore size, Nuclepore[R] membranes were placed between the nitrogen source and the Niskin bottles. The water obtained after filtering was retained in a polyethylene reservoir for a volume measurement.

Zooplankton samples "were collected on stepped oblique trawls with a 0.5 m zooplankton net with a mesh size of 202 μm. The bridle, net frame and net grommets were all constructed of brass so that there is a possibility of some contamination. All tows *were* done on plastic hydrowire with the hydroweight enclosed in a large plastic bag. In an attempt to minimize ship rust and paint contamination, the net was sent down closed until. it was beneath the boat's keel at which time it was opened and was closed at the same location when being brought aboard. The net was washed down with surface water collected in plastic buckets rather than using the ship's seawater system which would increase the potential for sample contamination via the introduction of metal particles. After removal of the plastic cod end containing the sample the net itself was cleaned with the seawater system, rinsed overboard, and stored in large plastic bags until the next sampling.

The zooplankton in the cod end were divided in a plastic splitter that had been rinsed with 4 N HCl and deionized water - one part for hydro-carbon and the other for trace metal analysis. Excess water was removed on a ring of No. 20 netting, and the concentrated zooplankton were stored in jars - acid rinsed glass jars - for the first two cruises and acid

leached polyethylene bottles for the last cruise. These samples were
frozen until they were returned to the laboratory.

At each station neuston samples were collected once during the
day and once at night. Samples were exposed to many possible forms of
contamination from either the portion of the water column being sampled
or from the sampling gear and technique. The neuston sled's structural
members were constructed from various forms of metal - many of them rusty.
Immediately in front of the net opening was a flowmeter with rusty
attachment hooks although on the winter cruise of 1976 this was exchanged
for a more suitable stainless steel flowmeter attached with shock
cords. The nets were continually exposed to airborne contaminants
between stations since the net remained uncovered. The greatest source
of contamination was felt to be the tar balls and other miscellaneous
objects often collected (cigarette filters, plastic bags, etc.) during
tOws. Although these objects comprise only a part of the neuston samples
they mask any changes occurring in the living biota.

Samples after collection were concentrated on a ring of No. 20
netting, at which time large tar balls and other objects (Sargassum,
sea grass, etc.) were removed with solid Teflon [R] tweezers. During the
second sampling period samples were frozen in acid-washed glass jars while
acid leached polyethylene bottles were used for the last sampling period.

Preparation of Samples

Prefiltration preparation of the Nuclepore[R] membranes consisted of a 48 hr desiccation using silica-gel after which they were weighed to the nearest microgram using a Perkin Elmer AD2 microbalance. Variability in weighing techniques was ±3 micrograms as determined by replicate weighings of membranes on consecutive days. Static electricity associated with the membranes was removed prior to each weighing by passing the membrane over a polonium source. The filters were then loaded into the Millipore filter heads which had just been acid leached two hours and washed, These filter heads were then placed in plastic bags for use at sea.

After the filtration was completed, it was necessary to remove residual sea water so the filter heads had ∿15 ml of deionized water sucked through with a Nalgene hand held plastic pump. The heads were then placed in plastic bags, sealed and refrigerated until return to the laboratory. Here the membranes were removed and placed in linear poly-ethylene funnels mounted in a laminar-flow clean bench, where they were further rinsed with about 12 ml of deionized water to remove any residual salt trapped on the filter. After a 48 hr desiccation period over silica gel, the pads were again weighed on the Perkin Elmer balance. The total suspended load was determined by dividing the difference between the tare and final weight by the liters of water which had been filtered.

To separate the particulate trace metals into a weak-acid soluble and refractory fractions, the dissolution process was carried out in two steps. The initial process whose purpose was to dissolve the carbonate materials and to remove the easily reduced metal hydroxyoxides from the

suspended matter, consisted of a two hour leach of the filter with a solution of acetic acid (25% v/v). The procedure was carried out by placing the folded filter in the same funnel assembly which was used to rinse the membrane and then filling them with approximately four ml of the acetic acid solution. After two hours the acid, retained in the funnel by a 'Teflon^R stopcock, was drained into an acid cleaned, one ounce linear polyethylene bottle. The filters were then triply washed with deionized water whit'n was drained into the bottle with the filtrate. To prevent the loss of metal species to the walls of the polyethylene bottles (Robertson, 1968), the pH was lowered to >1 by adding 0.5 ml of concentrated Ultrex^R(J. T. Baker) hydrochloric acid. The process was completed by transferring this solution to an acid washed, 25 ml volumetric flask, brought to volume and returned to the one ounce bottle.

This solution , referred to as the weak acid soluble fraction, contains the material collected on the filter that is susceptible to dissolution by a weak acid. This assumption is based upon the findings of Chester and Hughes (1966, 1967) that "an acetic acid (25% v/v) attack on a pelagic clay will liberate into solution those trace elements present in the carbonate minerals, those adsorbed onto mineral surfaces, and those precipitated in acid-soluble iron oxide minerals, but will only slightly affect those present in the ferro-manganese minerals." It was estimated by these authors that only 0.85% of the Fe_2O_3 contained in the pelagic clay tested was removed by the acetic acid.

After the weak-acid dissolution process the filters were returned to their respective vials for the second dissolution technique.

The second technique is designed to bring into solution the clay

minerals and refractory metal oxides unaffected by the weak-acid leach. This is carried out using an all-Teflon[R] decomposition vessel and is patterned after the techniques of Buckley and Cranston (1971). However, due to the limited amount of oceanic suspended materials which *is* normally available for analysis (<2000 μg) the procedure has been modified to reduce contamination and to optimize the analyses of such small amounts of material (Eggimann and Betzer, 1976). *The* modified procedure consists of placing the previously leached Nuclepore[R] filter with the remaining suspended material into an all-Teflon[R] bomb and adding 0.75 ml of concentrated Ultrex[R] hydrochloric acid with an Eppendorf[R] pipette. The vessel is closed and sealed with a lucite collar to prevent any loss of volatile constituents and placed in a 95°C hot water bath for 30 min. After removal, the vessel is cooled in a freezer which allows the bomb to be opened without the loss of volatile constituents.

This is followed by the injection of 0.25 ml of concentrated Ultrex[R] nitric acid, using an Eppendorf[R] pipette, at which point the vessel 'is closed and re-immersed in the controlled-temperature bath for a period of 30 min. After this heating and a subsequent cool-down, the vessel is opened and 0.050 ml of concentrated Ultrex hydrofluoric acid (0.05% of the final volume) is added , again using an Eppendorf[R] pipette. After the vessel is heated for a one-hour period in the water bath, it is again -cooled and opened. The filter is removed from the vessel using Teflon[R] tweezers and placed in a linear polyethylene funnel which drains into a 100 ml, acid-washed, LPE volumetric flask. The filter is unfolded, rinsed several times with deionized water, removed from the funnel and discarded .

The acid remaining in the decomposition vessel is poured into the funnel and the vessel is thoroughly rinsed with deionized water. After the funnel has been rinsed, the flask is brought to volume.

The digestion procedure is a reliable means of dissolving clay and refractory materials (Eggimann and Betzer, 1976). Treatment of between 100 and 2000 μg of the U.S.G.S. W-1 standard and the National Bureau of Standards Plastic Clay (98a) show that the recovery of the certified elements (Al, Cr, Fe, Mg and Si) was within one standard deviation of 100%, indicating that there was complete dissolution of these materials (Eggimann and Betzer, 1976). The amount of reference material used in testing the digestion procedure was chosen to encompass the normal range of open-ocean suspended matter samples. However, in this sample range, the low levels of the remaining certified elements (Fleischer, 1969) determined in this study (Cd, Cu, Pb and Ni) resulted in concentrations below the detection limit for flameless atomic absorption ('Table 1). It was therefore not possible to ascertain whether these elements were completely recovered, although the complete recovery of the other certified elements suggests that there was total destruction of the clay lattice and, therefore, complete recovery of the trace elements also.

Zooplankton and neuston samples upon return to the laboratory were dried in an oven at 65°c and then ground with an agate mortar and pestle for the first two sampling periods and with a porcelain lined spex mixer mill for the last sampling period. Previous experimentation had shown 0.5 g of dried zooplankton contained sufficient. quantities of trace metals for analysis. Half gram amounts of homogenized dried

Table 1. Comparison of Quality Control Organism Samples*
(concentrations in ppm dry weight)

Species Name	Sta. No.	Lab of Analysis+	Cd	Cr	Cu	Fe	Pb	Ni	Va[a]
Zooplankton	1206	USF	5.32	0.39	12.5	118	0.37	1.3	2.9
		TAMU	4.50	1.70	9.8	123	0.34	0.9	-
Zooplankton	1309	USF	4.66	0.98	19.4	224	0.94	3.2	1.0
		TAMU	4.10	1.20	29.0	257	0.62	3.7	-
Stenorhynchus seticornis	146	USF	0.40	0.16	25.6	56.4	0.22	<0.2	<0.4
		TAMU	0.53	0.98	35.6	50.0	2.7	<0.5	-
Cinachyra sp.	251	USF	0.36	0.80	6.5	15.	0.55	10.5	3.9
		TAMU	0.30	<0.10	7.0	17.	2.0	15.0	-
Clypeaster raveneli	II - m	USF	0.28	0.7.	6.8	148	0.56	0.6	1.0
		TAMU	0.30	0.4.	1.6	148	2.0	<0.5	-

* All samples collected from third sampling period
+ USF = University of South Florida (Betzer)
  TAMU = Texas A&M University (Presley)
a. Vanadium values not yet available from TAMU

zooplankton were weighed onto acid cleaned pyrex watch glasses with a four place Mettler balance. These watch glasses were then transferred to an International Plasma low temperature asher where the organic material was oxidized leaving the trace components. The ash on the watch glasses was then transferred into Teflon[R] decomposition vessels with solid Teflon[B] tweezers and three milliliters of Ultrex[R] nitric acid. Bombs were sealed, enclosed with a lucite collar and placed in a hot (95°C) water bath for six hours. After this time, they were cooled in a freezer, to allow opening and prevent the loss of any volatile components. This solution was then transferred to 50 ml acid-washed, LPE, volumetric flask, and brought to volume.

Sample Analysis

Elemental-analysis of all samples of both the suspended matter and organisms was carried out using atomic absorption spectroscopy. Perkin Elmer atomic adsorption spectrometers (Models 403 and 503) were used for the analysis of all elements except silica. Silica was determined on a Technicon Autoanalyzer II; the analyses for aluminum, cadmium, chromium, copper, iron , lead, nickel, and vanadium were made using a heated graphite atomizer (Perkin Elmer HGA2000 and HGA2100). Analysis of calcium was carried out with an air-acetylene flame. The standard conditions and instrument settings used in the flame and the flameless mode were the same as those recommended by Perkin Elmer (1971). All measurements were made in the absorbance mode, the peak heights being recorded on a Perkin Elmer Model 56 recorder. The injection of samples into the heated graphite atomizer was made using 25 or 50 $\mu\ell$ Eppendorf[R] pipettes.

The weak--acid soluble fraction of the samples was analyzed for calcium, cadmium, chromium, copper, iron, lead, nickel and vanadium. The elements analyzed with refractory fraction included aluminum, cadmium, chromium, copper, iron, lead, nickel., silica and vanadium. The zooplankton and neuston were analyzed for cadmium, chromium, copper, iron, lead, nickel and vanadium. The samples of each group were analyzed with a minimum of three combined standards whose concentrations bracketed those of the samples. New standards were prepared weekly from stock, 1000 ppm solutions (Fisher Certified Atomic Adsorption Standards) and were made up in the same acid matrix as the samples. Acid matrix blanks were also run with" standards to correct standards for any absorbance by blanks. Nuclepore membrane blanks were run for the suspended matter samples to correct for any contributions by the filter samples.

The absorbance of each sample was determined by averaging three peak readings. This average absorbance was converted to concentration by comparison with a working curve computed by first order regression analysis based upon three standards. To insure linearity of the standard curves only curves with correlation coefficients of 0.95 or greater were used to calculate sample concentration. In an effort to reduce operator bias, computation of the working curve and sample concentration was done by an IBM 360/65 computer.

Analytical Accuracy

Analysis of bovine liver and orchard leaves for their certified constituents with the procedure outlined for the zooplankton and neuston, produced recoveries within the range of the reported values (see Table 2). Intercalibration comparisons for the digestion and analysis of zooplankton

Table 2. Accuracy and Precision of Tissue Samples
(concentrations in ppm dry weight)

Element	Bovine liver (NBS)	Bovine liver (determined)*
Cd	0.27 ± 0.04	0.32 ± 0.03
Cu	193 ± 10	187 ± 8
Fe	270 ± 20	252 ± 12
Pb	0.34 ± 0.08	0.35 ± 0.1

* Mean values obtained from 20 separate analyses.

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and benthic macrofauna were performed between our laboratory and Texas A&M University (Presley).   The results are presented in Table 1 and show a good correlation.

Standard clay (W-1) in amounts bracketing our suspended loads were analyzed for the certified constituents with the procedure outlined for refractory suspended material.   Recoveries were within the range of reported values (see Table 3).

RESULTS AND DISCUSSION

Suspended matter, zooplankton and neuston samples were collected for the 1975-76 MAFLA program on four transects across the continental shelf of the northeastern Gulf of Mexico (see Figure 1). ' The transects will be referred to as the 1100, 1200, 1300 and 1400 transects, as shown in Figure 1.   Four stations were collected on each transect,   except the 1100 transect on which *only* three stations were sampled.

Sampling for the MAFLA program occurred during three seasons, but suspended loads and their composition indicated a bi-seasonality of water column conditions for the northeastern Gulf of Mexico. Mean suspended loads for the summer and fall were $109\pm69\,\mu g/\ell$, and $117\pm53\,\mu g/\ell$ respectively (one standard deviation).   A two-sample t-test of unpaired samples with equal variances found these values not to be significantly different at the 99% confidence level.   However, the mean suspended load for the winter was $278\pm210\,\mu g/\ell$, and a two sample t-test of unpaired samples found the winter values to be significantly different from the summer and fall at the 99% confidence level.   When equality of variances were tested between the winter and summer and fall, it was found that

Table 3. Elemental recovery of USGS-W1 standard clay.
Values presented as average precentage composition.*

Element	Standard Clay (W1)	Standard Clay (Determined)
SiO_2	52.6	52.4±1.4
Al_2O_3	16.9	14.7±0.7
Fe_2O_3	11.2	11.0±0.4
CaO	10.96	10.89±0.21

* Mean values obtained from 2 x 3 group analyses during fall and winter
sampling periods.

the variances about the means were significantly different. This is accounted for by the greater variability of the suspended loads for the winter *season.*

Physical processes appear to be the primary cause of the seasonal differences in suspended load. Pierce (1976) has noted that in the presence of' a strong halocline or thermocline, it would be doubtful. if the mass of suspended material is ever sufficient to overcome the density differences imposed by temperature and salinity changes between water masses. Furthermore, Brewer and others (1976) have concluded that advection along isopycnals is an important process in controlling the distribution of suspended matter. Physical data, collected concurrently with our suspended material, disclosed stable water conditions (established thermocline and halocline) during the summer and fall in the northeastern Gulf of Mexico. As might be expected, the suspended material which was collected at or above (10 m) the thermocline and/or halocline was dominated by biogenic (siliceous and calcareous) particles. The winter however, displayed unstable water conditions (no thermocline or halocline) and intense mixing due to winter storms, resulting in an alteration in both the quantity and composition of the suspended material.

An interesting corollary to the effect of physical processes on the suspended loads occurred during the second sampling period. Station 1205 was sampled immediately prior to Hurricane ELOISE and again after the hurricane. Suspended loads at the same station were doubled (128 µg/ℓ to 210 µg/ℓ) by the physical mixing due to the hurricane forces. Similar observations were made off the North Carolina coast where suspended

loads were more than doubled over pre-storm values by the passage of a hurricane, and within a week the concentration values had returned to pre-hurricane values (Rodolfo, et al., 1971).

The weak-acid soluble composition of Station 1205 after the hurricane showed a five-fold increase in calcium, a four-fold increase in iron, a doubling of lead and an increase in nickel. Calcium carbonate content of the suspended load increased from 5.3% to 23% after the hurricane. The refractory fraction of Station 1205 showed an increase in silica, iron, aluminum, and vanadium. Silica to aluminum ratios decreased after the hurricane (12 to 4.1) possibly due to an increased clay content of the suspended matter. 'Mineralogical analysis of the suspended material, although unable to determine an increase in suspended clay content, did find a shift in mineral composition following the hurricane. The percentage of chlorite, illite, and feldspar increased at the same time kaolinite decreased. Hurricanes generate physical mixing forces which alter the suspended loads and their composition. Similar physical processes (no thermocline, water of low stability, intense mixing) occur during the winter with the same results.

The composition of' the weak-acid soluble fraction of the suspended matter at the fifteen stations for the three sampling sessions is presented in Tables 4-6. This data also shows a bi-seasonality in the composition of the suspended matter. Weak-acid soluble calcium comprised a consistent percentage (1.76±1.55) of the suspended material for all stations during the summer and fall. It has been previously noted (BLM 2nd Quarterly Report) that calcium values for the fall were elevated in comparison to the

TABLE 4

B L M   S U S P E N D E D   M A T T E R

WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

WEAK ACID SOLUBLE FRACTION

CRUISE NUMBER 1

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	% AL 1X	% CA 1X	% CD 100X	% CR 100X	% CU 100X	% FE 10X	% NI 100X	% PB 100X	% SI 1X	% V 1X
1101	10.	145.	NA	0.57	0.11	*****	0.49	1.19	*****	1.38	*****	NA
1102	10.	73.	NA	0.45	0.09	*****	1.25	0.27	*****	0.46	*****	NA
1103	10.	17.	NA	1.23	0.15	*****	2.82	1.07	*****	*****	*****	NA
1204	10.	58.	NA	0.71	0.16	*****	1.30	1.54	*****	1.72	*****	NA
1205	10.	169.	NA	0.39	0.06	*****	0.97	0.30	*****	0.72	*****	NA
1206	10.	73.	NA	0.54	0.24	*****	4.21	0.38	*****	2.06	*****	NA
1207	10.	102.	NA	1.20	0.10	*****	1.22	0.41	*****	0.57	*****	NA
1308	10.	106.	NA	0.80	1.59	*****	3.19	1.77	*****	1.12	*****	NA
1309	10.	95.	NA	0.73	0.53	*****	1.83	0.51	*****	0.72	*****	NA
1310	10.	55.	NA	1.17	1.22	*****	4.43	1.13	*****	2.90	*****	NA
1311	10.	56.	NA	0.52	0.53	*****	2.81	0.56	*****	2.74	*****	NA
1412	10.	298.	NA	0.27	0.16	*****	0.77	1.39	*****	3.25	*****	NA
1413	10.	76.	NA	0.45	1.28	*****	2.26	1.20	*****	0.86	*****	NA
1414	10.	178.	NA	0.43	0.36	*****	1.10	0.37	*****	3.26	*****	NA
1415	10.	129.	NA	0.98	1.61	*****	3.42	1.05	*****	3.48	*****	NA

***** = NOT DETECTABLE

TABLE 5

m L M   S U S P E N D E D   M A T T E R
WEAK ACID SOLUBLE FRACTION
WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

CRUISE NUMBER 2

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	AL %1X	CA %1X	CD %100X	CR %100X	CU %100X	FE %10X	NI %100X	PR %100X	SI %1X	V %1X
1101	10.	197.	NA	2.09	0.34	*****	0.15	0.05	*****	0.24	*****	NA
1102	10.	53.	NA	2.34	0.29	*****	0.15	*****	*****	0.53	*****	NA
1103	10.	63.	NA	3.07	0.47	*****	0.20	0.46	*****	0.83	*****	NA
1204	10.	184.	NA	1.06	0.14	*****	*****	0.16	*****	0.32	*****	NA
1205	10.	128.	NA	2.12	0.14	*****	*****	0.07	*****	0.42	*****	NA
1215 *	10.	210.	NA	9.29	0.11	*****	0.05	0.27	6.12	0.90	*****	NA
1206	10.	104.	NA	2.31	0.26	*****	0.44	0.02	1.41	0.42	*****	NA
1207	10.	134.	NA	4.40	0.23	*****	0.94	0.15	*****	0.45	*****	NA
1308	10.	111.	NA	1.82	0.19	*****	0.21	0.54	4.85	0.69	*****	NA
1309	10.	54.	NA	1.38	0.17	*****	0.46	*****	*****	0.58	*****	NA
1310	10.	93.	NA	3.53	0.26	*****	0.52	*****	2.19	0.22	*****	NA
1311	10.	144.	NA	2.19	0.24	*****	*****	0.01	*****	0.35	*****	NA
1412	10.	158.	NA	0.65	0.69	*****	*****	0.17	*****	1.38	*****	NA
1413	10.	122.	NA	2.74	0.39	*****	0.75	*****	11.49	0.64	*****	NA
1414	10.	37.	NA	1.40	0.28	*****	0.14	0.18	*****	1.11	*****	NA
1415	10.	75.	NA	2.96	0.38	*****	0.27	0.27	*****	1.17	*****	NA

***** = NOT DETECTABLE

* After Hurricane ELOISE

TABLE 6

B L M   S U S P E N D E D   M A T T E R

WEAK ACID SOLUBLE FRACTION

CRUISE NUMBER ___3   WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	% AL	% CA	% CD	% CR	% CU	% FE	% NI	% PR	% SI	% V
			1X	1X	100X	100X	100X	10X	100X	100X	1X	1X
1101	10.	547.	NA	25.27	0.04	0.04	0.02	0.64	*****	0.73	*****	NA
1102	10.	437.	NA	13.28	0.02	0.05	*****	0.30	*****	0.29	*****	NA
1103	10.	70.	NA	6.37	0.12	*****	*****	0.11	*****	0.38	*****	NA
1204	10.	194.	NA	9.47	0.05	*****	*****	1.08	*****	0.31	*****	NA
1205	10.	57.	NA	4.14	0.28	*****	0.28	0.67	*****	0.25	*****	NA
1206	10.	758.	NA	10.18	0.04	0.05	*****	0.43	*****	0.31	*****	NA
1207	10.	399.	NA	16.54	0.03	0.06	*****	0.31	*****	0.44	*****	NA
1308	10.	231.	NA	0.18	0.07	0.01	*****	3.02	*****	0.30	*****	NA
1309	10.	143.	NA	0.36	0.11	*****	*****	0.83	*****	0.35	*****	NA
1310	10.	164.	NA	0.12	0.19	*****	*****	0.79	*****	*****	*****	NA
1311	10.	25.	NA	0.37	0.54	*****	0.47	0.74	*****	0.51	*****	NA
1412	10.	281.	NA	0.05	0.11	0.17	*****	21.77	*****	0.36	*****	NA
1413	10.	483.	NA	0.07	0.04	0.01	*****	6.31	*****	0.27	*****	NA
1414	10.	91.	NA	0.37	0.15	*****	*****	3.24	*****	0.78	*****	NA
1415	10.	294.	NA	0.28	0.09	0.02	*****	6.02	*****	0.52	*****	NA

***** = NOT DETECTABLE

first sampling period. The winter's weak-acid soluble calcium values are skewed with extremely high calcium values reported for the I and II Transects (X = 12.2%) and values of one to two orders of magnitude lower for the 111 and IV Transects ($\bar{X}$ 0.23%). Using the mean calcium composition and mean suspended loads of the I and II Transects, one finds that $CaCO_3$ comprises 1.8% and 6.2%, respectively, of the SPM for the summer and fall versus 30.5% of the SPM for the winter.

Weak-acid soluble cadmium remained consistent throughout the sampling periods. Chromium, which was non-detectable during the first two sampling sessions, was detected at certain stations during the winter where suspended loads were relatively large (>200 μg/ℓ). Copper and lead values were highest for the first sampling session and somewhat lower in both subsequent sampling sessions. Weak-acid soluble iron was lowest during the fall sampling period and comparable for summer and winter on all transects except the IV Transect of the winter. The iron concentration on the IV Transect was 8-36 times greater during the winter (i.e. $\bar{X}$ = 0.93% for winter, $\bar{X}$ = 0.021% for fall, X = 0.10% for summer) than in the fall and summer. Simultaneously, high refractory aluminum, iron, arrd silicon values suggest that this weak-acid soluble iron results from a poorly structured hydroxyoxide form in association with clay material. This is further discussed in another section of this report.

The composition of the refractory suspended matter for the three sampling periods is presented in Tables 7-9. Interesting trends and differences *were* evident in this fraction. Aluminum, iron, and silica concentrations *were* greatest during the winter sampling. This could have resulted from river runoff, resuspension of bottom sediments, and increased

TABLE 7

B - M S U S P E N D E D M A T T E R

REFRACTORY FRACTION

WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

CRUISE NUMBER 1

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	AL % 1X	CA % 1X	CD % 100X	CR % 100X	CU % 100X	FE % 10X	NI % 1X	PR % 100X	SI % 1X	V % 1X
1101	10.	45.	0.53	NA	0.02	0.31	0.09	4.56	*****	0.16	8.40	*****
1102	10.	73.	0.47	NA	*****	0.52	*****	4.34	*****	0.06	6.72	*****
1103	10.	17.	1.28	NA	0.08	0.99	0.69	10.96	*****	1.76	6.08	*****
1204	10.	58.	0.32	NA	0.05	0.62	0.31	3.91	*****	0.47	5.44	*****
1205	10.	169.	0.28	NA	0.03	0.40	0.25	2.62	*****	0.50	3.97	*****
1206	10.	73.	0.34	NA	*****	0.57	0.49	3.52	*****	0.16	6.04	*****
1207	10.	102.	0.30	NA	*****	0.57	0.47	3.18	*****	0.91	6.50	*****
1308	10.	106.	0.52	NA	0.06	0.59	4.53	4.96	*****	1.41	5.42	*****
1309	10.	95.	0.30	NA	0.10	0.53	5.00	4.18	*****	0.87	3.21	*****
1310	10.	55.	1.61	NA	0.15	0.92	3.36	3.25	*****	1.53	5.10	*****
1311	10.	56.	0.49	NA	0.11	0.53	4.26	2.60	*****	0.99	3.23	*****
1412	10.	293.	2.32	NA	0.05	0.35	0.79	10.29	*****	0.84	16.75	*****
1413	10.	76.	1.35	NA	0.04	0.34	2.78	8.86	*****	0.68	11.84	*****
1414	10.	178.	0.28	NA	0.02	1.25	0.81	2.15	*****	0.54	14.07	*****
1415	10.	129.	0.59	NA	0.97	0.77	4.32	3.47	*****	0.39	14.64	*****

***** = NOT DETECTABLE

TABLE 8

B L M   S U S P E N O E O   M A T T E R

REFRACTORY FRACTION

CRUISE NUMBER ___2___   WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	% AL	% CA	% CD	% CR	% CU	% FE	% NI	% PB	% SI	% V
			1X	1X	100X	100X	100X	10X	1X	100X	1X	1X
1101	10.	197.	0.17	NA	0.05	0.30	0.08	1.13	*****	0.98	5.06	*****
1102	10.	53.	0.09	NA	0.24	0.62	0.35	0.66	*****	1.30	4.74	*****
1103	10.	63.	0.15	NA	0.43	1.36	*****	4.71	*****	1.50	5.09	*****
1204	10.	184.	0.49	NA	0.03	0.53	*****	2.13	*****	0.53	4.95	*****
1205	10.	128.	0.45	NA	0.06	0.54	*****	1.90	*****	0.80	5.48	*****
1215 #	10.	210.	1.91	NA	0.05	0.69	0.12	7.12	*****	0.85	7.78	*****
1206	10.	104.	0.40	NA	0.07	0.47	0.20	1.71	*****	0.80	4.05	*****
1207	10.	134.	1.10	NA	0.14	0.34	0.24	4.34	*****	0.84	3.64	*****
1308	10.	111.	0.17	NA	0.34	0.93	*****	1.71	*****	1.01	4.61	*****
1309	10.	54.	0.23	NA	0.14	0.75	*****	1.22	*****	1.83	3.65	*****
1310	10.	93.	0.14	NA	0.08	5.63	*****	3.07	*****	0.76	2.79	*****
1311	10.	144.	0.63	NA	0.07	0.58	*****	2.55	*****	0.59	4.29	*****
1412	10.	158.	0.55	NA	0.75	1.61	2.41	3.56	*****	4.88	7.94	*****
1413	10.	122.	0.53	NA	0.04	1.71	*****	2.42	*****	2.14	6.35	*****
1414	10.	37.	0.53	NA	0.56	2.22	*****	5025	*****	4.44	11.20	*****
1415	10.	75.	0.40	NA	0.03	1.24	*****	1.51	*****	1.68	5.71	*****

***** = NOT DETECTABLE

* After Hurricane ELOISE

TABLE 9

B L M   S U S P E N D E D   M A T T E R

REFRACTORY FRACTION

CRUISE NUMBER ___ 3 ___   WEIGHT PERCENT ELEMENT OF THE SUSPENDED LOAD

STATION NUMBER	DEPTH IN M	SUSPENDED LOAD IN UG/LITER	% AL	% CA	% CD	% CR	% CU	% FE	% NI	% PB	% SI	% V
			1X	1X	100X	100X	100X	10X	1X	100X	1X	1X
1101	10.	547.	1.12	NA	*****	0.32	*****	4.82	*****	0.23	9.34	*****
1102	10.	·437.	1.75	NA	0.05	0.44	*****	7.65	*****	0.16	8.42	*****
1103	10.	70.	0.33	NA	*****	0.45	*****	2.07	*****	0.83	7.01	*****
1204	10.	194.	1.76	NA	*****	0.48	*****	8.02	*****	0.51	17.66	*****
1205	10.	57.	1.11	NA	1.10	0.83	*****	5.93	*****	1.69	19.55	*****
1206	10.	758.	1.71	NA	0.05	0.30	*****	6.03	*****	0.11	7.37	*****
1207	10.	399.	1.48	NA	*****	0.48	*****	7.39	*****	0.18	12.91	*****
1308	10.	231.	2.73	NA	*****	0.56	*****	10.56	*****	0.53	16.44	*****
1309	10.	143.	2.76	NA	*****	0.85	*****	12.72	*****	0.50	11.93	*****
1310	10.	164.	0.96	NA	0.42	0.57	4.17	8.46	*****	3.08	22.38	*****
1311	10.	25.	0.47	NA	*****	1.05	*****	3.58	*****	1.77	24.55	*****
1412	10.	281.	9.89	NA	*****	1.13	*****	28.33	*****	0.90	30.42	*****
1413	10.	483.	8.84	NA	*****	0.90	*****	38.28	*****	0.55	27.40	*****
1414	10.	91.	6.25	NA	*****	2.03	*****	32.35	*****	1.42	26.13	*****
1415	10.	294.	4.73	NA	*****	1.08	*****	24.74	*****	0.73	22.42	*****

***** = NOT DETECTABLE

primary prod uctivity (diatoms) . It is likely that all three mechanisms

are operating to elevate certain elements depending upon the sample location.

An excellent tool for evaluating the origin of the particles is the weight

ratios of each element to refractory aluminum (see Tables 1.0-15).

Refractory aluminum is used because it is not greatly concentrated by

organisms and has a primary source in clay minerals.

Diatoms, which utilize silica in their frustules , would, upon

analysis show a high silicon/aluminum ratio (>6) since they incorporate

minor amounts of aluminum (see Bennekom and Gaast, 1976). However, clays,

which are alumino-silicate minerals , would display low silicon/aluminum

ratios (2 - 6:1). Examination of Tables 10-15 show low silicon/aluminum

ratios on the IV Transect of the third sampling period when compared to

the IV Transects of the other sampling periods. These alumino-silicate

values result from an increased clay content of the winter suspended

loads ($\sim$60%). Whereas high calcium values occurred on the carbonate-

rich West Florida shelf (Davies and Moore, 1970), the high alumino-silicate

values occur on the Mississippi-Alabama shelf where clays are an important

part of the bottom sediments (Griffin, 1962). This reflection of shelf

sediment composition by the suspended matter implies that physical processes

were sufficient to resuspend and transport bottom and river material during

the winter in the northeastern Gulf of Mexico. The high silicon/aluminum ratios

found on other transects and at other times of the year indicate increased

silica concentrations resulting from biological sources or quartz sand which

would essentially dilute t'he existing clay. Suspended mineralogy work by

Dr. Huang found quartz to be present at 80% of the stations samples in

amounts sufficient to contribute significant quantities of silica.

TABLE 10

B L M   S U S P E N D E D   M A T T E R

WEAK ACID SOLUBLE FRACTION

WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

CRUISE NUMBER   1

STATION NUMBER	DEPTH IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL 1X	CD/AL 100X	CR/AL 100X	CU/AL 100X	FE/AL 10X	NI/AL 1X	PB/AL 100X	SI/AL 1X	V/AL 1X
1101	10.	145.	1.08	0.21	******	0.93	2.26	******	2.62	NA	******
1102	10.	73.	0.96	0.19	******	2.65	0.58	******	0.97	NA	******
1103	10.	17.	0.96	0.12	******	2.20	0.83	******	******	NA	******
1204	10.	58.	2.26	0.49	******	4.05	5.08	******	5.34	NA	******
1205	10.	169.	1.39	0.22	******	3.48	1.07	******	2.58	NA	******
1206	10.	73.	1.59	0.72	******	12.47	1.13	******	6.12	NA	******
1207	10.	102.	4.06	0.34	******	4.10	1.39	******	1.94	NA	******
1308	10.	106.	0.97	1.93	******	3.86	2.15	******	1.36	NA	******
1309	10.	95.	2.40	1.74	******	5.99	1.67	******	2.37	NA	******
1310	10.	55.	0.73	0.76	******	2.75	0.70	******	1.80	NA	******
1311	10.	56.	1.27	1.10	******	5.79	1.15	******	5.63	NA	******
1412	10.	293.	0.12	0.07	******	0.33	0.60	******	1.40	NA	******
1413	10.	76.	0.34	0.95	******	1.67	0.89	******	0.64	NA	******
1414	10.	178.	1.55	1.23	******	3.98	1.32	******	11.74	NA	******
1415	10.	129.	1.67	2.75	******	5.84	1.78	******	5.95	NA	******

****** = NOT DETECTABLE

TABLE 11

m L M   S U S P E N D E D   M A T T E R

WEAK ACID SOLUBLE FRACTION

WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

CRUISE NUMBER 2

STATION NUMBER	DEPTH IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL 1X	CD/AL 100X	CR/AL 100X	CU/AL 100X	FE/AL 10X	NI/AL 1X	PB/AL 100X	SI/AL 1X	V/AL 1X
1101	10.	197.	12.14	1.99	*****	0.89	0.32	*****	1.40	NA	*****
1102	10.	53.	26.91	3.39	*****	1.69	*****	*****	6.10	NA	*****
1103	10.	63.	20.29	3.08	*****	1.32	3.03	*****	5.49	NA	*****
1204	10.	184.	2.16	0.29	*****	*****	0.33	*****	0.65	NA	*****
1205	10.	128.	4.76	0.31	*****	*****	0.16	*****	0.94	NA	*****
1215	10.	210.	4.86	0.05	*****	0.03	0.14	0.03	0.47	NA	*****
1206	10.	104.	5.84	0.65	*****	1.11	0.05	0.04	1.07	NA	*****
1207	10.	134.	3.99	0.21	*****	0.85	0.14	*****	0.41	NA	*****
1308	10.	111.	10.61	1.06	*****	1.23	3.13	0.28	4.01	NA	*****
1309	10.	54.	6.05	0.77	*****	2.04	*****	*****	2.55	NA	*****
1310	10.	93.	26.46	1.91	*****	3.82	*****	0.16	1.62	NA	*****
1311	10.	144.	3.22	0.35	*****	*****	0.02	*****	0.52	NA	*****
1412	10.	156.	1.17	1.24	*****	*****	0.31	*****	2.43	NA	*****
1413	10.	122.	5.15	0.74	*****	1.40	*****	0.22	1.20	NA	*****
1414	10.	37.	2.63	0.52	*****	0.26	0.34	*****	2.09	NA	*****
1415	10.	75.	7.46	0.95	*****	0.69	0.68	*****	2.95	NA	*****

***** = NOT DETECTABLE

TABLE 12

B L M   S U S P E N D E D   M A T T E R

WEAK ACID SOLUBLE FRACTION

WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

CRUISE NUMBER   3

STATION NUMBER	DEPTH IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL 1X	CD/AL 100X	CR/AL 100X	CU/AL 100X	FE/AL 10X	NI/AL 1X	PB/AL 100X	SI/AL 1X	V/AL 1X
1101	10.	547.	22.53	0.04	0.03	0.02	0.57	*****	0.65	NA	*****
1102	10.	437.	7.58	0.01	0.03	*****	0.17	*****	0.17	NA	*****
1103	10.	70.	19.49	0.36	*****	*****	0.34	*****	1.17	NA	*****
1204	10.	194.	5.39	0.03	*****	*****	0.61	*****	0.18	NA	*****
1205	10.	57.	3.74	0.25	*****	0.25	0.61	*****	0.22	NA	*****
1206	10.	758.	5.97	0.02	0.03	*****	0.25	*****	0.18	NA	*****
1207	10.	399.	11.16	0.03	0.04	*****	0.21	*****	0.30	NA	*****
1308	10.	231.	0.06	0.04	0.01	*****	1.11	*****	0.11	NA	*****
1309	10.	143.	0.13	0.04	*****	*****	0.32	*****	0.13	NA	*****
1310	10.	164.	0.12	0.20	*****	*****	0.63	*****	*****	NA	*****
1311	10.	25.	0.79	1.16	*****	1.01	1.60	*****	1.09	NA	*****
1412	10.	281.	0.00	0.01	0.02	*****	2.20	*****	0.04	NA	*****
1413	10.	483.	0.01	0.01	0.00	*****	0.71	*****	0.03	NA	*****
1414	10.	91.	0.06	0.02	*****	*****	0.52	*****	0.13	NA	*****
1415	10.	294.	0.06	0.02	0.00	*****	1.27	*****	0.11	NA	*****

***** = NOT DETECTABLW

TABLE 13

m LM SUSPENDED MATTER

CRUISE NUMBER 1

REFRACTORY FRACTION

WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

STATION NUMBER	DEPTH IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL 1X	CO/AL 100X	CR/AL 100X	CU/AL 100X	FE/AL 1X	NI/AL 1X	PB/AL 100X	SI/AL 1X	V/AL 1X
1101	10.	145.	NA	0.03	0.59	0.17	0.67	*****	0.31	15.97	*****
1102	10.	73.	NA	*****	1.10	*****	0.92	*****	0.13	14.29	*****
1103	10.	17.	NA	0.06	0.77	0.54	0.65	*****	1.37	4.74	*****
1204	10.	58.	NA	0.16	1.94	0.97	1.21	*****	1.46	16.90	*****
1205	10.	169.	NA	0.11	1.46	0.90	0.94	*****	1.79	14.27	*****
1206	10.	73.	NA	*****	1.68	1.44	1.04	*****	0.48	17.89	*****
1207	10.	102.	NA	*****	1.94	1.59	1.07	*****	3.08	22.26	*****
1308	10.	106.	NA	0.07	0.71	5.50	0.60	*****	1.72	6.59	*****
1309	10.	95.	NA	0.32	1.74	16.40	1.37	*****	2.84	10.54	*****
1310	10.	55.	NA	0.09	0.57	2.03	0.20	*****	0.95	3.16	*****
1311	10.	56.	NA	0.23	1.10	8.76	0.54	*****	2.03	6.65	*****
1412	10.	298.	NA	0.02	0.15	0.34	0.44	*****	0.36	7.21	*****
1413	10.	76.	NA	0.03	0.25	2.06	0.65	*****	0.50	8.77	*****
1414	10.	178.	NA	0.07	4.52	2.90	0.77	*****	1.96	50.68	*****
1415	10.	129.	NA	1.65	1.32	7.38	0.59	*****	0.66	25.33	*****

***** = NOT DETECTABLE

TABLE 14

B J M   S U S P E N D E D   M A T T E R

CRUISE NUMBER 2

REFRACTORY FRACTION

WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

STATION DEPTH NUMBER IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL 1X	CO/AL 100X	CR/AL 100X	CU/AL 100X	FE/AL 1X	NI/AL 1X	PB/AL 100X	SI/AL 1X	V/AL 1X
1101	10.	197.	NA	0.30	1.77	0.44	0.66	*****	5.69	29.47	*****
1102	10.	53.	NA	2.71	7.12	4.07	0.76	*****	14.92	54.44	*****
1103	10.	63.	NA	2.86	9.01	*****	3.12	*****	9.89	33.67	*****
1204	10.	184.	NA	0.97	1.17	*****	0.43	*****	1.07	10.03	*****
1205	10.	128.	NA	0.18	1.21	*****	0.43	*****	1.80	12.28	*****
1215	10.	210.	NA	0.03	0.36	0.05	0.37	*****	0.44	4.07	*****
1206	10.	104.	NA	0.18	1.18	0.52	0.43	*****	2.03	10.24	*****
1207	10.	134.	NA	0.12	0.31	0.22	0.39	*****	0.76	3.30	*****
1308	10.	111.	NA	2.01	5.40	*****	0.99	*****	5.86	26.82	*****
1309	10.	54.	NA	0.64	3.32	*****	0.54	*****	6.04	16.06	*****
1310	10.	93.	NA	0.59	41.62	*****	2.27	*****	15.59	20.61	*****
1311	10.	144.	NA	0.11	0.85	*****	0.39	*****	0.67	6.32	*****
1412	10.	158.	NA	1.35	2.90	4.35	0.54	*****	8.60	14.32	*****
1413	10.	122.	NA	0.07	3.21	*****	0.45	*****	4.01	11.94	*****
1414	10.	37.	NA	1.05	4.19	*****	0.99	*****	8.38	21.10	*****
1415	10.	75.	NA	0.09	3.12	*****	0.38	*****	4.25	14.40	*****

***** = NOT DETECTABLE

TABLE 15

8 L M   S U S PE ND ED   M A T T E R

REFRACTORY FRACTION

CRUISE NUMBER   3   WEIGHT RATIO OF EACH ELEMENT TO REFRACTORY ALUMINUM

STATION NUMBER	DEPTH IN M.	SUSPENDED LOAD IN UG/LITER	CA/AL	CD/AL	CR/AL	CU/AL	FE/AL	NI/AL	PB/AL	SI/AL	V/AL
			1X	100X	100X	100X	1X	1X	100X	1X	1X
1101	10.	547.	NA	*****	0.28	*****	0.43	*****	0.21	8.32	*****
1102	10.	437.	NA	0.03	0.25	*****	0.44	*****	0.09	4.81	*****
1103	10.	70.	NA	*****	1.37	*****	0.63	*****	2.69	21.43	*****
1204	10.	194.	NA	*****	0.27	*****	0.46	*****	0.29	10.04	*****
1205	10.	57.	NA	1.00	0.75	*****	0.54	*****	1.53	17.68	*****
1206	10.	758.	NA	0.03	0.18	*****	0.35	*****	0.06	4.32	*****
1207	10.	399.	NA	*****	0.33	*****	0.50	*****	0.12	8.71	*****
1308	10.	231.	NA	*****	0.21	*****	0.39	*****	0.20	6.03	*****
1309	10.	143.	NA	*****	0.31	*****	0.46	*****	0.18	4.33	*****
1310	10.	164.	NA	0.43	0.59	4.35	0.88	*****	3.21	23.29	*****
1311	10.	25.	NA	*****	2.25	*****	0.77	*****	3.80	52.71	*****
1412	10.	281.	NA	*****	0.11	*****	0.29	*****	0.09	3.08	*****
1413	10.	483.	NA	*****	0.10	*****	0.43	*****	0.06	3.10	*****
1414	10.	91.	NA	*****	0.32	*****	0.52	*****	0.23	4.18	*****
1415	10.	294.	NA	*****	0.23	*****	0.52	*****	0.16	4.74	*****

***** = NOT DETECTABLE

The distribution of nearshore particulate iron has been found to be dominated by the presence of detrital silicates, although the concentration of marine organisms in surface waters can also be significant (Spencer, et at., 1972). It is therefore interesting to note the consistency of the Fe/Al ratios for the winter and fall sampling (see Figure 2), except at those stations during the fall where the Cr/Al ratios are very high and then the Fe/Al ratios are also high (Stations 1310, 1103). A correlation coefficient of 0.96 was calculated between Al and Fe for the fall and winter (excluding Stations 1310 and 1103 at the fall), whereas a correlation coefficient of 0.75 was calculated between AS and Fe for the summer. The lower correlation of the early summer is believed to have resulted from increased biological activity by amorphous silica secreting organisms, diatoms. The high silica concentrations and high Si/Al ratios on all the transects during the summer indicate that diatoms dominate the suspended composition and incorporating Fe, unsupported by aluminim during growth. However the fall and winter periods were dominated by carbonate organisms and resuspended sediments respectively, and here the particulate iron is associated with detrital silicates. Thus it would seem that particulate iron in surface water of the northeastern Gulf of Mexico is primarily controlled by detrital silicates "although biological organisms are important seasonally, depending on the concentration and type of organisms present.

Refractory iron concentrations were greatly elevated on the IV Transect during the winter compared to other sampling seasons, This obviously resulted from increases in the contribution of clay
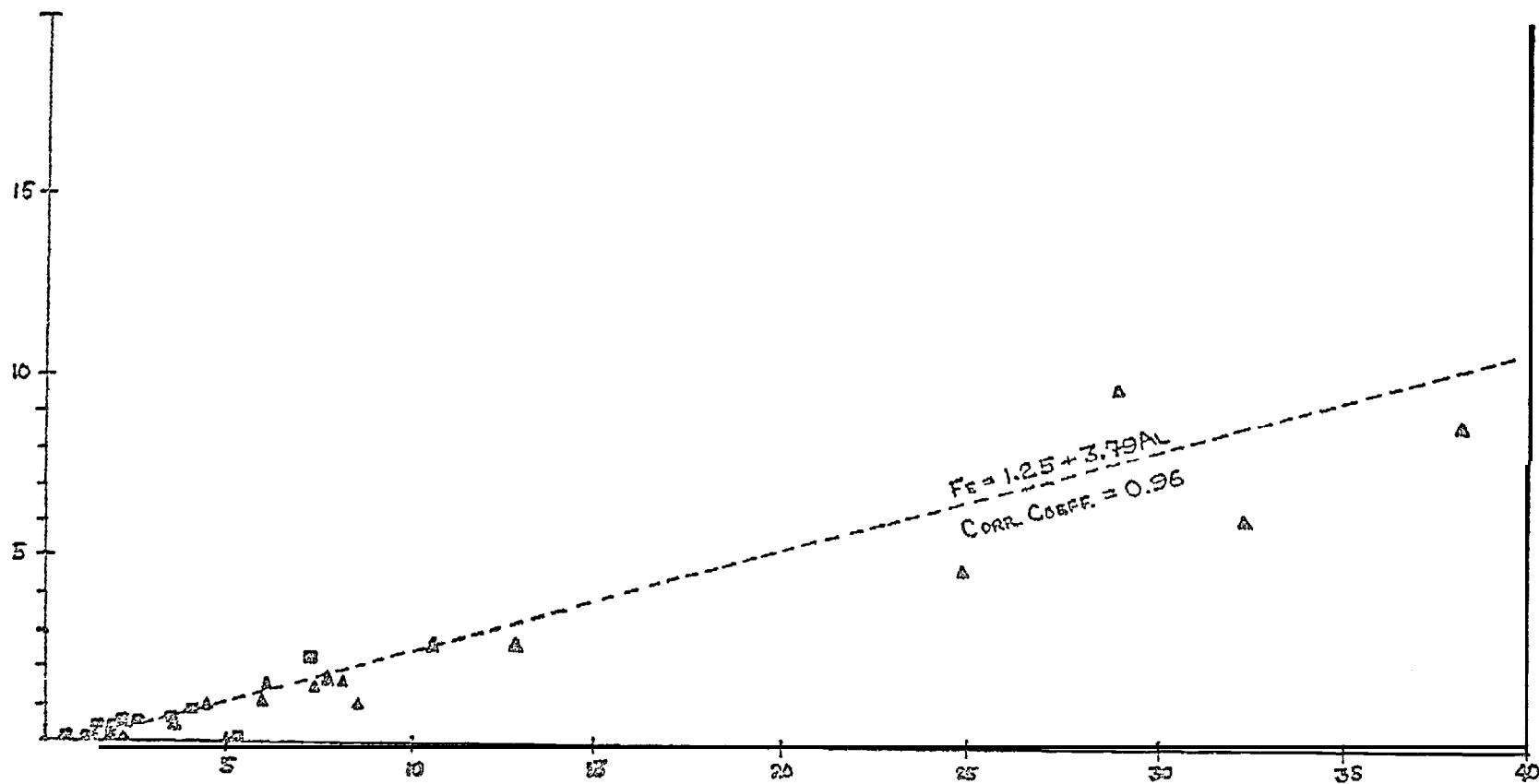
Figure 2.   Refractory Al versus Refractory Fe
for second and third sampling sessions.

minerals made to the suspended matter.

[.mineralogical analysis of the suspended fraction from the IV Transect showed that smectite and kaolinite were dominant during the winter. This assemblage of suspended clays should have a Fe/Al ratio of approximately 0.055 for smectite (Degens, 1965) and 0.051 for kaolinite (Weaver and Pollard, 1976). However, our data for the IV Transect shows Fe/AL ratios of 0.29 - 0.52. This discrepancy can be explained by the existence of free ferric oxide particles and/or the adsorption of iron to the clay particles. Tieh and Pyle (1972) described cores from the same region composed of composite clay particles stained with iron oxides and/or hydroxides. The concurrently high weak-acid soluble and refractory iron concentrations for the IV Transect indicate iron to be partitioned at different oxidation states possibly indicative of recently deposited sediments and/or river runoff.

Refractory chromium showed some interesting trends during the three sampling periods. During all seasons, chromium appears to increase as one goes from the I to the IV Transects, High Cr/Al ratios are generally found at those stations with high Si/Al ratios, and it is possible that biological mechanisms might, in part, be responsible for these increased chromium concentrations in suspended matter.

Refractory lead is another element that appears -to be influenced by biological activity. High Pb/Al ratios are often matched with high Si/Al ratios and this is particularly evident during the fall sampling session. It is noted that high Pb/Al and high Cr/Al ratios appear to occur at those stations where there are low suspended loads, which could result in artificially high element-to-aluminum ratios because of the

increased possibility of contamination. However, with elevated Cr/Al ratios one should expect elevated Fe/Al ratios if contamination occurred. This appears to be the case for Stations 1103 and 1310 during the fall but still does not explain many other stations of the summer, fall and winter which have elevated Cr/Al and Pb/Al ratios occurring with high Si/Al ratios.

It is difficult to discuss refractory copper, nickel and vanadium since they were often at the detection limits of our analytical procedure.

Comparison and interrelation of our data with the mineralogy of suspended matter and sediments (Dr. W. Huang) provides further insights into our results. The dominant clay mineral on the Mississippi-Alabama shelf is smectite with both chlorite and chlorite-vermiculite mixed layers present in trace amounts (Table 16). If the suspended mineraology data is examined for the IV Transect (Table 17) one finds smectite present at only one station for the summer and fall but present at all stations during the winter. Thus it would appear that physical processes are causing the suspended mineralogy to more closely reflect the sediments mineral composition during the winter. 'This is consistent with our *conclusion* that clays dominate the suspended material during the winter, but not during the remainder of the year on the IV Transect.

Suspended mineralogy from the winter found carbonates (aragonite, low magnesium calcite, high magnesium calcite and dolomite) present in appreciable amounts on the I Transect, and to quote Dr. Huang,"These suggest that some stirring up from the bottom sediments may have occurred." This data corroborates our elevated carbonate values found on the I and II Transects during the winter. Similarly, we also attribute

Table 16. Clay Mineral Content (%) of Surface Sediments from the MAFLA Sites (Preliminary Results)

Station No.	Smectite	Chlorite of Chlorite-Vermiculite mixed layer	Illite	Kaolins
2101	8	64	11	17
2102	10	54	10	26
2103	T	48	8	43
2104	T	62	5	32
2105	o	39 "	14	47
2106	24*	28	15	33
2207	o	54	11	35
2208	7	44	8	41
2209	7	45	6	42
2211	4	45	5	46
2212	37	21	13	29
2313	46	13	10	31
2316	7	43	6	44
2317	3	39	9	49
2318	8	39	5	48
2419	3	39	4	54
242o	5	37	6	52
2421	4	29	2	65
2422	12	22	5	61
2423	15	16	4	65
2424	11	20	8	61
2425	5	39	8	48
2426	14	29	8	49
2427	45	9	8	38
2528	11	34	3	52
2529	9	36	4	51
2530	18	35	4	43
2531	16	23	7	54
2532	24	28	10	38
2533	27	21	10	42
2534	24	20	4	52
2535	37	15	7	41
2536	49	5	8	38
2637	74	2	3	21
2638	82	5	4	9
2639	75	3	7	15
2640	61	6	10	23
2641	55	T	12	32
2642	43	6	17	34
2643	76	T	6	17
2644	49	4	14	33
2645	61.	4	9	26

* Expanded mixed layers

Table 17. The Content (%) of Clay Minerals in Suspended Particulate Matter from 10 m Depth on the West Florida Shelf

July 14, 1975 and July 21, 1975

Station No.	Smectite	Chlorite	Illite	Kaolinite	Talc
1101		18	19	40	23
1.102	T	7	25	27	*41*
1 1 0 3		12	18	34	36
1204		15	29	27	29
1205		15	15	20	50
1206		19	17	33	31
1207		T	38	62	T
1308		17	16	26	41
1309		6	23	24	47
1310	T	11	13	30	57
1311		32	20	42	16
1412	11	18	18	43	10
1413		T	46	54	–
1414		T	23	28	49
1415		11	12	16	61

T Trace Amount

Table 17. The Content (%) of Clay Minerals in
continued   Suspended Particulate Matter from
             10 m Depth on the West Florida
             Shelf

September 16, 1975 and October 3, 1975

Station No.	Smectite	Chlorite	Illite	Kaolinite	Talc
1101		9	I-6	38	37
1102		6	11	23	60
1103			14	35	51
1204		11	T	26	63
1205		9	10	79	2
1205a		31	31	38	T
1206		T	20	32	48
1207		10	10	56	24
1308		T	18	34	48
1309		T	25	50	25
1310		26	T	49	25
1311			40	60	
1412		24	24	24	28
1413			T	43	57
1414			43	57	
1415	26	38		36	T

1205a before hurricane
1205 after hurricane

T   Trace Amount

Table 17.   The Content (%) of Clay Minerals in
continued   Suspended Particulate Matter from
10 m Depth on the West Florida
Shelf

January, 1976

Station no.	Smectite	Chlorite	Illite	Kaolinite	Talc
1101		31	9	44	16
1102		15	10	51	24
1103		19	17	15	49
1204	–	20	8	54	18
1205	–	18	23	31	28
1206		24	5	71	0
1207	9	12	9	65	5
1308	T	13	11	66	10
1309		16	27	30	27
1310	–	T	11	70	19
1311	*	*	*	*	*
1412	63	2	9	26	o
1413	68	2	12	18	0
1414	83	T	7	10	T
1415	74	T	9	13	5

T   Trace Amount
*   Not enough sample

resuspension of bottom sediments as the primary carbonate enrichment process.

The zooplankton collected displayed. a remarkable consistency in their concentrations of various elements (see Table 18). However, iron levels were elevated on the IV Transect during the winter sampling period.

The mean iron concentration for the winter (1192 ppm) was 4-8 times that of the summer (253 ppm) or the fall (116 ppm). The concurrently high iron values for the weak-acid soluble and refractory fraction of the SPM indicate that suspended matter could be the cause of the zooplankton's elevated concentrations. In order to determine how much clay would have to be in our 0.5 gram zooplankton samples in order to elevate the iron values%a.hove their previous levels, a short calculation was made.

The difference between the mean iron concentration for the winter and that of the summer and fall for the IV Transect is 1008 μg Fe/g of zooplankton. Knowing the mean Fe/Al ratio (0.41) of the refractory SPM for the IV Transect of the winter , one would need ⌐1,230 μg of Al/0.5 g of zooplankton to contain sufficient Fe. According to Huang the suspended mineralogy of the clay minerals was approximately 72% smectite and 17% kaolinite for the IV Transect. Aluminum constitutes 20% of kaolinite (Weaver and Pollard, 1 ? 6 7) and 11% of smectite (Degens, 1965). Using these assumptions one finds that 11.2 mg of clay (2.2% of sample mass) are required to elevate iron levels in zooplankton.

This calculation is based on the assumption that all the iron we found in the zooplankton is adsorbed on or contained in clay lattices. If a free ferric oxide form existed, then this amount of clay would

B L M   Z O O   P L A N K T O N
TOTAL ELEMENT ANALYSIS

CRUISE NUMBER __1__   ELEMENT CONCENTRATION IN PARTS PER MILLION

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	A L	CA	co	CR	Cu	FE	NI	PB	SI	v
			1X	1X	1X	1X	1X	1X	1X	1X	1X	1X
1101	0.	509.	NA	NA	4.36	0.21	8.07	61.	1.18	0.72	NA	8.95
1102	0.	512.	NA	NA	6.93	0.67	10.72	116.	1.50	2.17	NA	13.02
1103	0.	510.	NA	NA	13.66	0.91	28.98	106.	3.$0	1.94	NA	5.65
1204	0.	480.	NA	NA	7.35	00$4	11.08	151.	1.48	1.75	NA	3.95
1205	0s	533.	NA	NA	7.52	0.52	26.34	126.	1.86	3.63	NA	12.22
1206	0.	524.	NA	NA	8.33	0.38	9.40	67.	1.40	1.29	NA	7.40
1207	0.	535.	NA	NA	6.95	0.25	9.67	51.	1.78	1.24	NA	5.97
1308	0.	995.	NA	NA	5.34	0.16	14.42	67.	1.93	O*86	NA	1.01
1309	0.	1047.	NA	NA	4.96	0.06	8.09	54.	0.88	0.40	NA	2.17
1310	0.	993.	NA	NA	5.57	0.69	11.59	83.	2.23	2.58	NA	1.07
1311	0.	909.	NA	NA	11.85	1.06	15.86	161.	3.59	3.28	NA	1.26
1412	0.	1003.	NA	NA	10.96	3.23	14.83	553.	2.29	3.03	NA	4*59
1413	0.	994.	NA	NA	4.20	0.42	15.78	178.	1.94	1.28	NA	11.92
1414	0.	997.	NA	NA	2.82	0.28	9.55	86.	1.57	0.98	NA	15.32
1415	0.	1008.	NA	NA	4.26	0.75	31.95	197.	3.79	2.91	NA	7645

***** = NOT DETECTABLE

B L M Z O O P L A N K T O N

TOTAL ELEMENT ANALYSIS

CRUISE NUMBER ___ 2 ___   ELEMENT CONCENTRATION IN PARTS PER MILLION

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	AL	CA	CD	CR	CU	FE	NI	PB	S1	V
			1X	1X	1X	1X	1X	1X	1X	1X	1X	1X
1101	0.	518.	NA	NA	2.09	0.17	9.78	55.	3.15	0.25	NA	1.69
1102	0.	567.	NA	NA	2.91	0.16	14.29	69.	3.46	0.86	NA	5.66
1103	0.	491.	NA	NA	17.95	0.37	21.66	60.	5.27	0.79	NA	0.80
1204	0.	590.	NA	NA	2.50	0.38	12.15	77*	0.91	1.26	NA	5.40
1205	0.	505.	NA	NA	10.70	0.30	17.05	97.	1.59	3 0 5 4	NA	*****
1215	0.	521.	NA	NA	2.80	1.05	21.88	192.	1.56	4.22	NA	O*37
1206	0.	543.	NA	NA	3.01	0.31	12.43	79.	2.14	2.01	NA	1.42
1207	0.	519.	NA	NA	3.19	0.17	12.19	62.	1.05	1.17	NA	0.47
1308	0.	476.	NA	NA	2.83	0.33	13.30	54.	0.98	O*69	NA	4.75
1309	0.	502.	NA	NA	10.65	0.17	12.44	60.	3.34	1.07	NA	0.19
1310	0.	526a	NA	NA	12.70	3.81	23.44	52.	9.74	1.18	NA	.2.05
1311	0.	555.	NA	NA	12.17	0.70	19.77	144.	9.22	2.09	NA	0.28
1412	0.	486.	NA	NA	2.65	0.21	88.01	84.	1.23	0.66	NA	1.02
1413	0.	505.	NA	NA	3*O7	0.71	16.71	49.	1.27	2.52	NA	34.32
1414	0.	506.	NA	NA	23.99	0.63	20.34	94.	5.52	3.37	NA	0.92
1415	0.	472.	NA	NA	22.19	5.46	42.40	237.	9.75	13.37	NA	1.04

***** = NOT DETECTABLE

BLM ZOOPLANKTON

TOTAL ELEMENT ANALYSIS

CRUISE NUMBER   3   ELEMENT CONCENTRATION IN PARTS PER MILLION „

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	AL	CA	CD	CR	CU	FE	NI	PB	S1	V
			1x	1x	1X	1X	1X	1X	1X	1X	1X	1X
1101	0.	519.	NA	NA	9.57	1.59	14.54	381.	1.68	3.26	NA	1.60
1102	0.	537.	NA	NA	7.86	0.89	14.18	113.	2.07	3*44	NA	0.99
1103	o*	522.	NA	NA	6.78	0.19	10.54	53.	3.76	0.67	NA	2.35
1204	0.	·486.	NA	NA	3*12	O*54	33.26	173.	1.26	1.78	NA	1.32
1205	0.	597.	NA	NA	4.61	0.18	12.55	82.	0.90	0.16	NA	1.21
1206	0.	526.	NA	NA	5.33	0.39	12.48	118.	1.32	0.37	NA	2.88
1207	0.	540.	NA	NA	6.16	*****	17.61	60.	1.25	O*34	NA	2.17
1308	0.	500.	NA	NA	8.51	2.79	12.47	1892.	2.10	7.89	NA	4.79
1309	0.	506.	NA	NA	4.66	0.98	19.43	224.	3.23	0.94	NA	1.77
1310	0.	513.	NA	NA	6.84	0.50	13.44	244.	3.41	12.49	NA	15.22
1311	0.	453.	NA	NA	8.21	0.33	18.16	100.	5.49	0.69	NA	2.05
1412	0.	558.	NA	NA	3.97	1.98	11.89	*****	2.45	1.17	NA	25.41
1413	0.	516.	NA	NA	2.69	1.00	24.09	1542.	3.54	0.97	NA	3.66
1414	0.	490.	NA	NA	2.85	0.32	17.12	280.	1.54	0.16	NA	3*O4
1415	0.	505.	NA	NA	6.12	0.59	17.70	892.	2.12	0.80	NA	6.83

***** = NOT DETECTABLE

obviously be reduced. The high weak-acid soluble iron values for the

IV Transect indicate that a reduced form of' iron could be available,

Assuming the dry weight of an organism to be 1/10 of its wet weight, then

11.2 mg of clay would be 0.2% of the zooplankton (wet wt.) or 2% of

zooplankton (dry wt.). Jørgensen (1966) has indicated that copepods

show little selectivity in assimilating particles from $1-50\,\mu m$ in diameter

and can efficiently sweep water volumes ranging from 72 to >2,000 ml

$24\ hr^{-1}\ mg\ dry\ wt^{-1}$. Since the dominant zooplankton of the offshore

stations was Paracalanas, a calanoid copepod and of the inshore station

(1411) was Paracalanas, Eucalanas, and fish eggs (data from Caldwell and

Maturo) 11.2 mg of clay does not seem to be an unreasonable amount.

The concentration of the remaining elements (Cd, Cr, Cu, Fe, Ni,

Pb, V) is in good agreement with those reported by other authors (see

Table 19). Variations that did occur between stations and transects were

felt to be due to taxonomic composition, population turnover rates and

geographic location.

Neuston concentrations for the 2nd and 3rd sampling periods *are*

presented in Tables 20-21. Due to the abundance of foreign objects and

ease of possible contamination, the neuston data is difficult to evaluate.

It is interesting that in every case tar balls were noted prior to ashing,

there were high vanadium concentrations. No readily discernible trends

could be found between time of day, geographical location or period of

sampling. It will probably be necessary to improve our sampling procedures

before any reasonable biologic interpretations can be made.

Suspended loads and chemical composition of the suspended matter

indicate a. hi-seasonal water structure for the Northeastern Gulf of Mexico.

Table 19. The average trace metal content (ppm) of zooplankton in the eastern Gulf of Mexico in the summer and fall, 1975 and winter, 1976.

	Fe	Cr	Ni	Cd	V	Pb	Cu
1st sampling session (June, 1975)	137.1 ±124.30	0.67 ± .75	2.08 ± .93	7.00 ±3.1	6.80 ±4.67	1.87 ±1.02	15.09 ± 7.76
2nd sampling session (Sept., 1975)	91.55 ± 54.14	0.94 ±1.5	3.76 ±3.22	8.47 ±7.53	4.02 ±8.58	2.44 ±3.14	22.37 ±19.14
3rd sampling session (Jan., 1976)	549.6 ±701.1	0.88 ± .76	2.41 ±1.25	5.82 ±2.17	5.02 ±6.68	2.34 ±3.45	15.30 ± 3.63
Martin and Knauer (1972) Monterey Bay	344		3.9	6.2		6.9	5.4
Sims (1975)	1,181		3.9	1.9		10.0	16.2
Windom (1972)				3.9		32.0	82.0
Martin (1970)	1,200		42.0			49.3	41.0
Topping (1972)				1.0		15.0	16.2
Martin and Knauer (1974) Pacific	348			2.4		7.2	15.44

TABLE 20

L M   N E U S T O N

TOTAL ELEMENT ANALYSIS

ELEMENT CONCENTRATION IN PARTS PER MILLION

CRUISE NUMBER   2

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	AL 1X	CA 1X	CD 1X	CR 1X	CU 1X	FE 1X	NI 1X	PB 1X	SI 1X	V 1X
110	0.	516.	NA	NA	1.81	0.02	8.60	47.6	0.77	0.16	NA	1.51
110	0.	516.	NA	NA	3.75	4.61	16.40	75.5	1.80	12.27	NA	0.71
112	0.	509.	NA	NA	2.49	0.68	15.37	415.0	2.70	0.79	NA	2.31
112	0.	547.	NA	NA	2.08	0.11	18.17	162.0	2.14	0.65	NA	0.94
117	0.	503.	NA	NA	3.58	0.09	49.74	58.3	3.86	1.20	NA	0.85
117	0.	545.	NA	NA	3.39	0.33	21.04	137.0	9.47	0.40	NA	7.00
117	0.*	514.	NA	NA	10.40	1.39	24.47	98.6	5.73	10.14	NA	1.13
120	0.*	530.	NA	NA	1.98	1.91	13.64	388.0	1.93	7.47	NA	2.02
120	0.*	513.	NA	NA	2.66	0.46	17.80	236.0	2.42	2.13	ND	5.10
120	0.*	532.	NA	NA	1.19	0.63	19.78	123.0	2.32	2.58	ND	2.05
120	0.*	501.	NA	NA	0.48	0.48	6.89	146.0	1.77	1.33	NA	1.14
120	0.*	523.	NA	NA	1.34	1.63	28.75	228.0	2.74	2.64	NA	2.16
12	0.	534.	NA	NA	2.75	0.35	12.19	127.0	3.54	1.14	NA	1.40
120	0.	509.	NA	NA	4.17	0.42	51.13	358.0	5.59	1.92	NA	6.13
120	0.	514.	NA	NA	3.21	0.28	13.92	161.0	4.50	0.94	NA	1.21
120	0.	513.	NA	NA	4.52	0.88	18.43	1460.0	5.50	1.14	NA	3.08

✱✱✱✱✱ = NOT DETECTABLE

TABLE 20 - continued
B L M   N E U S T O N
TOTAL ELEMENT ANALYSIS

CRUISE NUMBER ___2   E L E M E N T   C O N C E N T R A T I O N   I N   P A R T S   P E R   M I L L I O N

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	AL	CA	CD	CR	CU	FE	NI	PB	S1	V
			1X	1X	1X	1X	1X	1X	1X	1X	1X	1X
1308	0.	512.	NA	NA	2.25	0.49	23.86	94.0	1.34	2.91	NA	1.33
1308	0.	529.	NA	NA	2.93	2.13	17.11	293.0	2.19	12.13	NA	0.93
1309	0.	506.	NA	NA	6.00	0.66	17.37	538.0	6.08	1.75	NA	*****
1309	c.	488.	NA	NA	6.19	1.39	24.28	1796.0	3.66	5.59	NA	0.41
1310	0.	467.	NA	NA	26.85	1.27	20.60	3130.0	9.25	5.34	NA	11.40
1310	0.	489.	NA	NA	0.40	0.04	22.10	675.0	6.34	0.99	NA	2.57
1311	0.	498.	NA	NA	0.31	0.36	19.60	1500.0	8.66	1.45	NA	6.43
1311	0.	498.	NA	NA	3.95	0.08	57.90	186.0	2.33	0.45	NA	1.11
1412	0.	502.	NA	NA	1.00	0.83	11.80	467.0	2.07	1.11	NA	0.37
1412	0.	495.	NA	NA	0.66	0.56	14.90	360.0	2.22	0.99	NA	2*20
1413	0.	501.	NA	NA	1.19	0.45	13.50	673.0	2.31	0.86	NA	0.94
1413	0.	501.	NA	NA	0.35	0.49	26.40	464.0	6.59	1.64	NA	2.65
1414	0.	477.	NA	NA	3.52	0.30	23.20	1090.0	11.25	0.99	NA	1.98
1414	0.	493.	NA	NA	5.42	0.18	33050	29.2	1.05	1.60	NA	1.27
1415	0.	492.	NA	NA	2.71	0.84	38.30	2920.0	$.53	0.94	NA	10.20
1415	0.	512.	NA	NA	1.66	0.11	28.40	74.4	1.97	2.92	NA	*****

***** = NOT DETECTABLE

TABLE 21

B L M   N E W T O N

TOTAL ELEMENT ANALYSIS

ELEMENT CONCENTRATION IN PARTS PER MILLION

CRUISE NUMBER 3

STATION NUMBER	DEPTH IN M	SAMPLE MASS MILLIGRAMS	AL (1X)	CA (1X)	CD (1X)	CR (1X)	CU (1X)	FE (1X)	NI (1X)	PB (1X)	SI (1X)	V (1X)
1101	0.	499.	NA	NA	2.59	2.34	7.45	487.6	1.74	3.55	NA	2.85
1101	0.	545.	NA	NA	1.56	2.38	12.80	906.2	2.62	1.74	NA	0.70
1102	0.	514.	NA	NA	6.61	3.11	20.77	1249.2	2.96	4.45	NA	0.91
1102	0.	579.	NA	NA	4.41	0.48	15.82	109.8	1.96	0.12	NA	*****
1103	0.	572.	NA	NA	3.11	0.24	8.26	140.9	8.23	0.50	NA	3.92
1103	0.	505.	NA	NA	6.04	0.18	7.16	42.6	14.90	0.17	NA	1.40
1204	0.	557.	NA	NA	2.86	6.08	6.41	195.8	2.64	14.46	NA	12.30
1204	0.	566.	NA	NA	2.56	1.62	11.81	602.3	2.17	4.40	NA	34.56
1205	0.	496.	NA	NA	4.45	0.20	7.78	102.7	1.03	0.17	NA	0.56
1205	0.	518.	NA	NA	2.71	0.26	13.44	65.6	1.02	0.10	NA	*****
1206	0.	530.	NA	NA	6.56	0.18	7.33	103.8	1.99	*****	NA	0.54
1206	0.	504.	NA	NA	3.10	0.22	11.31	62.7	1.04	0.88	NA	*****
1206	0.	493.	NA	NA	6.76	0.79	9.50	114.3	1.28	0.25	NA	0.97
1207	0.	498.	NA	NA	6.88	0.64	7.01	159.3	1.29	0.10	NA	1.43
1207	0.	506.	NA	NA	7.03	0.29	10.80	87.6	1.59	0.04	NA	0.73
1308	0.	505.	NA	NA	3.58	1.58	10.20	465.8	1.60	2.17	NA	1.54

***** = NOT DETECTABLE

TABLE 21 - continued

B L M   N E U S T O N

TOTAL ELEMENT ANALYSIS

ELEMENT CONCENTRATION IN PARTS PER MILLION

CRUISE NUMBER 3

STATION NUMBER	DEPTH IN M	SAMPLE MASS (MILLIGRAMS)	AL 1X	CA 1X	CD 1X	CR 1X	CU 1X	FE 1X	NI 1X	PB 1X	SI 1X	V 1X
1308	0.	490.	NA	NA	1.85	0.78	6.51	300.2	0.92	1.44	NA	1.97
1309	0.	674.	NA	NA	4.37	3.44	12.55	387.6	3.85	11.61	NA	0.47
1309	0.	502.	NA	NA	5.71	0.45	16.02	139.1	6.76	0.38	NA	0.89
1310	0.	521.	NA	NA	5.53	2.50	8.60	124.1	2.34	0.30	NA	2.66
1310	0.	470.	NA	NA	5.63	2.61	15.76	234.6	2.91	36.41	NA	2.37
1311	0.	491.	NA	NA	6.77	0.31	8.68	76.1	3.84	2.47	NA	1.16
1311	0.	538.	NA	NA	5.43	0.15	16.28	50.7	2.25	0.56	NA	*****
1412	0.	542.	NA	NA	2.30	1.29	13.93	377.7	5.91	1.84	NA	5.85
1412	0.	581.	NA	NA	1.96	4.34	13.22	657.7	2.00	19.04	NA	4.31
1412	0.	511.	NA	NA	1.60	0.91	9.27	306.4	1.15	1.36	NA	5.32
1413	0.	557.	NA	NA	1.74	0.05	6.73	55.9	1.29	0.44	NA	0.80
1413	0.	579.	NA	NA	6.81	0.54	11.57	345.5	1.93	0.59	NA	2.18
1414	0.	459.	NA	NA	2.72	0.56	11.69	196.3	1.91	10.09	NA	1.47
1414	0.	564.	NA	NA	2.90	0.34	13.09	178.6	1.64	0.44	NA	0.46
1415	0.	505.	NA	NA	2.04	0.38	9.64	232.0	2.01	0.15	NA	10.81
1415	0.	661.	NA	NA	2.39	0.29	23.03	184.3	1.03	0.44	NA	0.99

***** = NOT DETECTABLE

The chemical composition also appears to reflect an environment of resuspended bottom sediments during the winter which is being transported to the 183 m contour on some stations (1103, 1415) . During the remainder of the year the suspended loads appear to be dominated by biological particles both carbonate and siliceous.

Suspended matter composition is a reflection of the *source* of the particles whether biogenic *or* terrestrial and their relative abundance. Knowledge of the composition of the suspended matter at various geographic locations, time of year and depth could serve as an invaluable tool for detecting and tracing elevated metal pollutant levels.

Zooplankton which were collected on oblique trawls of the water column showed high iron concentrations at those stations having increased amounts of clay-rich suspended material. Zooplankton, reflecting this seasonal change in suspended matter, are likely to reflect similar significant alterations of the water column in the case of injected pollutants. Oil, known to contain elevated levels of nickel and vanadium (Smith, et al., 1975), is biodegraded by marine bacteria (ZoBell, 1962) which in turn are a portion of the food source for zooplankton. Since nickel and vanadium were detectable in all zooplankton samples, any significant increases in their "concentrations could be detected and hopefully correlated with changes in their hydrocarbon content.

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